COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE if not in response to a program announcement/solicitation enter NSF 15-1

NSF 15-534 03/24/15

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

[redacted]

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

OAC - Campus Cyberinfrastrc (CC-NIE)

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856000545

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Northern New Mexico College

AWARDEE ORGANIZATION CODE (IF KNOWN)

0002378000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Northern New Mexico College
921 Paseo de Onate
Espanola, NM. 875322649

NAME OF PRIMARY PLACE OF PERF

Northern New Mexico College

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE

Northern New Mexico College
921 Paseo de Onate
Espanola ,NM ,875322649 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **CC*DNI Campus Design: Northern's Network Expansion for Large Science and Engineering Data Flows**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 350,000	24 months	10/01/15	

THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☒ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____
PHS Animal Welfare Assurance Number _____
☒ FUNDING MECHANISM Equipment

☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)

☒ COLLABORATIVE STATUS
Not a collaborative proposal

PI/PD DEPARTMENT
Engineering

PI/PD POSTAL ADDRESS
921 Paseo de Onate
Espanola, NM 875322649
United States

PI/PD FAX NUMBER
505-747-2180

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Email Address
PI/PD NAME [redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CO-PI/PD [redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CO-PI/PD [redacted]	[redacted]	[redacted]	[redacted]	[redacted]
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative (or Equivalent) or Individual Applicant

By electronically signing and submitting this proposal, the Authorized Organizational Representative (AOR) or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding conflict of interest (when applicable), drug-free workplace, debarment and suspension, lobbying activities (see below), nondiscrimination, flood hazard insurance (when applicable), responsible conduct of research, organizational support, Federal tax obligations, unpaid Federal tax liability, and criminal convictions as set forth in the NSF Proposal & Award Policies & Procedures Guide,Part I: the Grant Proposal Guide (GPG). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U.S. Code, Title 18, Section 1001).

Certification Regarding Conflict of Interest

The AOR is required to complete certifications stating that the organization has implemented and is enforcing a written policy on conflicts of interest (COI), consistent with the provisions of AAG Chapter IV.A.; that, to the best of his/her knowledge, all financial disclosures required by the conflict of interest policy were made; and that conflicts of interest, if any, were, or prior to the organization's expenditure of any funds under the award, will be, satisfactorily managed, reduced or eliminated in accordance with the organization's conflict of interest policy. Conflicts that cannot be satisfactorily managed, reduced or eliminated and research that proceeds without the imposition of conditions or restrictions when a conflict of interest exists, must be disclosed to NSF via use of the Notifications and Requests Module in FastLane.

Drug Free Work Place Certification

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent), is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

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This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

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The undersigned certifies, to the best of his or her knowledge and belief, that:
(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.
(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

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Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:
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(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:
(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR) (This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the Certification Pages, the Authorized Organizational Representative is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research. The AOR shall require that the language of this certification be included in any award documents for all subawards at all tiers.

CERTIFICATION PAGE - CONTINUED

Certification Regarding Organizational Support

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that there is organizational support for the proposal as required by Section 526 of the America COMPETES Reauthorization Act of 2010. This support extends to the portion of the proposal developed to satisfy the Broader Impacts Review Criterion as well as the Intellectual Merit Review Criterion, and any additional review criteria specified in the solicitation. Organizational support will be made available, as described in the proposal, in order to address the broader impacts and intellectual merit activities to be undertaken.

Certification Regarding Federal Tax Obligations

When the proposal exceeds $5,000,000, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal tax obligations. By electronically signing the Certification pages, the Authorized Organizational Representative is certifying that, to the best of their knowledge and belief, the proposing organization:
(1) has filed all Federal tax returns required during the three years preceding this certification;
(2) has not been convicted of a criminal offense under the Internal Revenue Code of 1986; and
(3) has not, more than 90 days prior to this certification, been notified of any unpaid Federal tax assessment for which the liability remains unsatisfied, unless the assessment is the subject of an installment agreement or offer in compromise that has been approved by the Internal Revenue Service and is not in default, or the assessment is the subject of a non-frivolous administrative or judicial proceeding.

Certification Regarding Unpaid Federal Tax Liability

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal Tax Liability:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has no unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

Certification Regarding Criminal Convictions

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Criminal Convictions:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has not been convicted of a felony criminal violation under any Federal law within the 24 months preceding the date on which the certification is signed.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME [redacted]	Electronic Signature	Mar 24 2015 2:11PM

TELEPHONE NUMBER	EMAIL ADDRESS	FAX NUMBER
[redacted]	[redacted]	505-747-2180

PROJECT SUMMARY

Overview:

Northern New Mexico College (Northern or NNMC) proposes to establish a dedicated network fabric and Science DMZ in support of its multidisciplinary engineering and science programs. This research network will be entirely separate from the existing general-use Campus Enterprise Network (CEN) currently shared by all faculty, staff, and students at Northern's Espanola campus. As a dedicated research network, firewalls and filters will not be implemented. The proposed network will deliver high-speed connectivity among the campus Data Transfer Nodes (DTNs), Northern's Aguila supercomputer, storage nodes, and multiple laboratories serving biology, chemistry, environmental science, and engineering programs. The project design will focus on isolating high-throughput research functions through data paths of at least 10 Gbps of capacity.

Intellectual Merit :

The infrastructure upgrade will move Northern forward toward vertical integration with regional networks by replacing the current border router with a new, high-speed capable aggregate service router. This upgrade is essential for increasing the effectiveness of moving Terabytes of data associated with faculty research and undergraduate research training. Specifically, the cyberinfrastructure enhancements will upgrade Northern's current use of manual and station wagon-types of transfers to move data on operationally efficient, high-speed connections to/from partners in larger cities in New Mexico, including the National Center for Genome Resources (Santa Fe) and the University of New Mexico (Albuquerque). The planned integration to national networks will reinforce the growing undergraduate research activities with partners such as Texas A&M, Pennsylvania State University, the University of South Florida, and Cold Spring Harbor Laboratory, with whom transfers of large datasets will be enabled under projects such as the NSF Infrastructure and Training to Bring Next Generation Sequence (NGS) into Undergraduate Education. The new research network will allow intra-campus integration, facilitating transfers of at least 10 Gbps of data sets of solar energy variables, fluid dynamics, DNA/RNA sequencing, invertebrate neural activity, and high-resolution imagery, which are severely limited by the current 100 Mbps CEN capacity.

Broader Impacts :

Northern is the only institution of higher education in the state to be designated as Hispanic- and Native American-serving. The PI and one Co-PI are Hispanic, and the second Co-PI is Native American. All senior personnel and IT Department staff are Hispanic, mirroring the 72% Hispanic and 11% Native American student demographic at the College. Northern has continuously evolved to serve these underrepresented populations from a secondary boarding school (1909), to a vocational training school, to a community college, and finally to the only baccalaureate degree granting institution in north-central New Mexico (2004). Northern's recent development of Engineering, Biology, and Environmental Science programs in 2007/2008 have greatly increased access to STEM four-year degrees for northern-central New Mexicans. This project represents the next step in closing the STEM education gap that prevents Hispanics, the fastest growing ethnic group in the nation's labor force, and Native Americans from entering STEM professions, a national economic and security priority. The proposed network upgrades will permit faculty and students to engage in high-throughput RNA-sequence analysis, high-resolution fluid dynamics, and network optimization research, which currently are not available or impractical. By implementing remote experiment control features to lab equipment, this project will also help address the geographical challenge of campus access experienced by students living in remote mountain villages, especially during winter months. Northern proposes to develop remote undergraduate research experiences that do not compromise vital hands-on activities known to be essential for the success of minority populations studying STEM. These unique features will be shared with key state partners: the Northeast Regional Education Cooperative (NEREC) of high schools, the New Mexico Skill Up Network (SUN Online) of community colleges, and the University of New Mexico, the main research institution in New Mexico. By becoming the STEM bridge for northern-central New Mexico, Northern will strengthen the STEM higher education pipeline.

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*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

1. Introduction

This network expansion project to support data-intensive research and education represents the next step in the evolutionary path Northern New Mexico College (Northern or NNMC) has set for itself. As a higher education institution that serves its students with high demand educational programs driving economic development in a "Chronic Poverty" region, the project will improve Northern's network infrastructure to accommodate increasing research activities in STEM, as supported by twelve vignettes.

Founded in 1909, Northern evolved from a secondary boarding school to a vocational training school to New Mexico's first designated community college in 1977, and finally to a baccalaureate degree granting institution in 2004. Northern's rapid STEM-related growth in the past few years has attracted recognition from industry and higher education communities, as summarized in Table 1. The Information Engineering Technology (IET) program was created in 2008, accredited by ABET [1] in 2014, and applauded by ABET for its high-level of undergraduate research activities (see Section 2). Northern's baccalaureate degrees in Biology and Environmental Science, and the recently created Associate degree in Chemistry, represent driving forces in STEM education in northern New Mexico (NM). Despite their recent inception, the Biology and Environmental Science programs were recently highlighted by the Society for the Advancement of Chicanos and Native American Scientists (SACNAS) [2] for their research initiatives. These are snapshots of how Northern, a small rural institution with a 72% Hispanic, 11% Native American, 61% female, and 78% financial aid-eligible student population, is distinguishing itself as the only regional, four-year degree granting institution in north-central New Mexico.

Table 1. Snapshots of science and engineering highlights.

#	Year	Description
1	2008	Bachelor's degrees offered in Information Engineering Technology (IET) and Mechanical Engineering. Emphasis of the IET is in networking and security.
2	2008	Bachelor's degrees offered in Biology and Environmental Science.
3	2013	Northern's recognized, among more than 2,000 institutions from US and Canada, by Cisco for going "Above and Beyond" in preparing students in the networking field through applied undergraduate research.
4	2013	Solar grid "Prosperity Project," partnered by Northern, University of New Mexico (UNM), Sandia National Labs, and the Public Service Company of New Mexico (PNM), is named finalist of the "2013 Platts Global Energy Award." The project includes data transfers from Albuquerque to Northern's Española campus (80-mile distance).
5	2013	Northern's recognized by the Advancement of Chicanos and Native American Scientist (SACNAS), for its Biology and Environmental Science programs.
6	2014	Northern/IET program becomes i) the first and only ABET-accredited program in the northern part of the state, ii) one in four institutions in the state and iii) the only non-PhD, non-Master granting institution with a program accredited by ABET.
7	2015	Northern starts offering an Associate degree in Chemistry.

1.1 Need for Proposed Network Improvements

Central to the item list in Table 1 is the need for enhanced networking infrastructure and data flows that are indispensable for science and engineering research, training and educational programs. Undergraduate research, in collaboration with industry and regional research institutions, including the University of New Mexico (UNM), is a signature of Northern's STEM programs. An example includes the "PNM Prosperity Project", where Gigabytes (GBs) of data generated by solar panels in Albuquerque were transmitted to Northern's Española campus, an 80-mile distance, and stored locally for intra-campus transfer. Network limitations, preventing GBs of data transfers from storage nodes to campus labs, did not prevent the project from being nominated for a "2013 Platts Global Energy Award" [3].

To manage enormous sets of data, including plant and animal genomics, bioinformatics, invertebrate neurobiological modeling information, and DNA/RNA dataset collaboration with institutions such as the National Center for Genome Resources (NCGR), data files are currently transferred manually or at low rates from remote sites to campus working stations/offices, or via periodic station wagon-type transfers.

The twelve use cases reflect the need for Northern to continue its network evolution to become the regional center and premier research institution in northern New Mexico and to serve its interdisciplinary research activities involving teams of faculty, students, and partnering institutions.

The college proposes to establish a dedicated Science DMZ, separate from the existing Fast Ethernet (100 Mbps) Campus Enterprise Network (CEN) (see Fig. 1), that will initially support nine faculty and twelve research/teaching activities, as listed in Table 2. To accommodate new faculty, the Science DMZ will be designed for rapid up-scaling and capacity expansion as bandwidth requirements evolve. The network needs described below highlight the requirements characteristic of the applications employed by science and engineering research faculty. The upgrades are critical for intra-campus high-performance data transfers and for connection to regional partners and to New Mexico's point-of-presence (POP), Albuquerque GigaPop (ABQG), which connects to Internet2, UNM's Science DMZ, and other institutions. The plan includes:

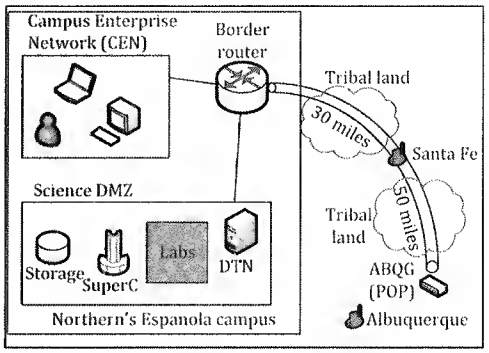

Fig. 1. This CC*DNI project will upgrade the border router (BR) needed for the campus connection to the Albuquerque GigaPop (ABQG), NM's exchange point, and regional networks. The new Science DMZ will also permit intra-campus high-speed data transfer between Northern's supercomputer, storage devices, DTNs, and labs.

- Deployment of a new border router (BR) capable of aggregating at least 40 Gbps, to replace the current 100 Mbps BR.
- Deployment of the Science DMZ composed of 10/40 Gbps access/distribution layer switches connecting science and engineering labs, Northern's supercomputer, storage devices, and Data Transfer Nodes (DTNs). End devices will be connected to the network through 10 Gbps access switches, which will connect to layer 3 distribution switches.
- Installing two purposed-built DTNs. Northern's collaborators include the NCGR, located in Santa Fe, UNM, located in Albuquerque (see Fig. 1), New Mexico State University (NMSU), located in Las Cruces, University of South Florida (USF), Texas A&M, and others. The BR and DTNs upgrades would permit the vertical integration of Northern's network with regional and national networks, and facilitate high-speed data transfers to/from collaborators. Data transfers to national collaborators must go through ABQG and follow long distances. A high-speed connection to ABQG will allow Northern to expand its out-of-state collaborations. With TCP, it is essential to have DTNs for data transfers beyond metro distances, since small latencies introduced would cause retransmissions and performance degradation [4].
- Implementing measurement points with perfSONAR [5] and Netflow [6] to quantify intra- and inter-campus performance, and to collect traffic information to be used for future upgrades.

1.2 Partnership with Campus IT Department and Regional Leadership Institution

The network will be deployed by the Information Technology (IT) Department and the College of Engineering and Technology. Northern has a strong partnership with UNM, the leadership institution in New Mexico. UNM is supporting Northern in the technical design of the Science DMZ and in the improvement of the CEN. UNM will continue the support in the eventual deployment of the Science DMZ. Both institutions have a record of successful collaboration resulting from prior NSF support.

2. Science and Engineering Projects, Application Drivers, and Requirements

Table 2 lists the faculty researchers collaborating on this proposal. The data-intensive projects, many that are supported by NSF, NIH, and US Department of Energy (DOE) science grants, include associate collaborations and sharing requirements as drivers of network capacity needs. The vignettes describe nine faculty research activities, two educational initiatives for undergraduate education in science and engineering, and a regional collaboration with community colleges and high schools to implement engaged teaching and research experiences via remote experiment control.

Table 2. Faculty researchers, network requirements, and research areas.

Researcher	Network Requirements	Research Area
[redacted]	High-speed intra-campus: transfers of TBs (e.g., 50 Tbits flows) of solar data from storage nodes/DTNs to multiple labs and workstations. High-speed WAN: data transfers between Northern's Espanola campus and PNM's Prosperity site.	Networked Control Systems, Solar Systems
[redacted]	High-speed intra-campus: flow transfers of tens of TBs of data across network test-bed.	Computer Networks, Optimization
[redacted]	High-speed intra-campus: transfers of 1.6 TBs per simulation experiment from storage node to supercomputer.	Fluid Dynamics and Parallel Programming
Institutional Eng.	Low latency/minimal packet inspection: remote experiment control to lab equipment.	Engineering Education for Undergrad. Research
[redacted]	High-speed WAN and intra-campus: transfers of TBs of DNA/RNA genome sequencing to/from regional and national collaborators, and to/from storage nodes/DTNs and labs.	Plant Genomics
[redacted]	High-speed WAN and intra-campus: transfers of TBs of DNA/RNA genome sequencing to/from regional and national collaborators, and to/from storage nodes/DTNs and labs.	Genomics, Bioinformatics, Neuroecology
[redacted]	High-speed intra-campus: transfers of TBs (e.g., 20-TB videos) of high-resolution of invertebrate neural activities.	Neurobiology, Ecophysiology
[redacted]	High-speed intra-campus: storage and transfers of TBs of chemical variables.	Agricultural Science
[redacted]	High-speed intra-campus and WAN: transfers of 0.5-5 TBs of high-resolution imagery.	Ecological Modeling, Simulation, GIS
[redacted]	High-speed intra-campus: transfers of TBs (e.g., 10-TB flows) from/to supercomputer to/from storage nodes.	Numerical Modeling
Institutional Science	High-speed intra-campus and WAN: transfers of TBs from NCGR and CSHL to Northern for next-gen. sequencing. High speed intra-campus data transfers from storage nodes to labs.	Science Education; Next-gen. Sequence Analysis
Institutional STEM	Low latency/minimal packet inspection: remote experiment control to lab equipment.	NM SUN Online Consortium / Northeast Regional Cooperative

2.1 [redacted] (Engineering; Networked Control Systems, Solar Systems); Co-PI

[redacted] research interests are in Networked Control Systems and Solar Systems. Recent undergraduate research activities include the "PNM Prosperity Energy Storage Project [7]," (Prosperity) in which he served as PI for Northern. Prosperity is the nation's first energy storage facility fully integrated into a utility power grid. Lead by the Public Service Company of New Mexico (PNM), this collaborative project also included Northern, UNM, and Sandia National Laboratories. The Prosperity project, funded by the US Department of Energy (DE-OE0000230), features one of the largest combinations of battery storage and photovoltaic energy in the nation. Prosperity's goal is to manage solar and other renewable

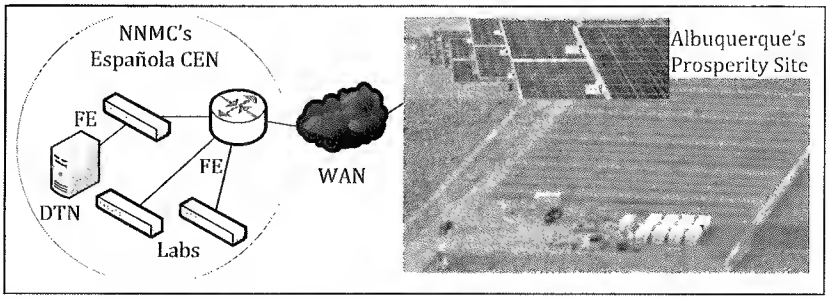

Fig. 2. Prosperity Project. WAN data flow from Albuquerque's Prosperity site to Northern's Española CEN network includes hundreds of variables per second. Intra-campus flow is achieved at Fast Ethernet (FE) rate.

energies when they are most needed. Grid-connected solar photovoltaic panels and an energy storage system comprised of two kinds of batteries are linked to a computer bank that collects up to 220 data points (electric power, irradiance, temperature, etc.) per second. [redacted] group analyzed the behavior of variables to characterize Prosperity's power generation [8, 9]. Fig. 2 illustrates the scheme used. Data generated by Prosperity was transmitted to Northern, stored locally, transferred intra-campus, and analyzed asynchronously by faculty and students.

For 220 data points per second, some at 30 samples per second, 64 bit-precision, the storage capacity needed is above 10 Terabits per year. For a five-year power generation characterization, the data flow from the storage/DTN to campus labs would require approximately 200 hours at Fast Ethernet (FE) rate, without considering overhead. Due to this limitation, the research has only focused on a few variables such as irradiance and power generation, using lower sampling rates. Increasing intra-campus capacity would increase the research output. Similarly, as described in Section 3.3, Northern is planning to increase the WAN capacity to Albuquerque to connect to the ABQG exchange point. The first step will be achieved by replacing the current Cisco 2800 border router. Connecting to ABQG will enable Northern to transfer large data sets faster and thus engage in more projects with partner institutions. [redacted] students carrying out research in solar systems are supported by NSF SSTEM Award 1259993.

2.2 [redacted] (Engineering; Computer Networks, Optimization); PI

[redacted] interests include Intrusion Prevention System (IPS) models for enterprise networks. Current models face unprecedented challenges deriving from the "Internet of Everything" that generates trillions of GBs transported by LANs/WANs. Multimedia traffic generated by more than 12 billion devices represents more than 65% of today's traffic, and will grow to 79% by 2018 [10]. Dr. Crichigno and collaborators at the University of South Florida are devising multi-IPS schemes for enterprise networks shown in Fig. 3 [11]. A challenge of this architecture lies in traffic discrimination based on reputation to alleviate inspection load at IPSs. Scheduling decisions based on reputation can relieve overload sensors from inspecting traffic considered to be secure, in order to optimally use the scarce computational resources.

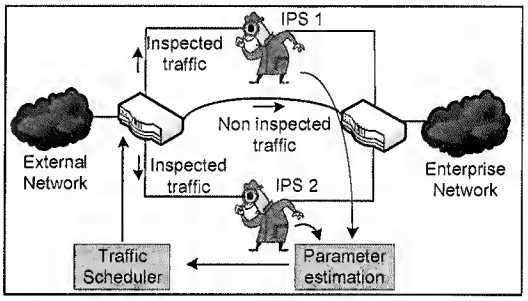

Fig 3. Multi-sensor IPS architecture. Massive traffic from/to an external network is inspected by two sensors. The discrimination of traffic, based on reputation, is intended to alleviate the IPS loads by allowing *secure* traffic to bypass sensors.

[redacted] group has developed optimal linear programming schemes that maximize the amount of suspicious traffic inspected by sensors, based on flow reputation. The current Networking Lab used for experiments is isolated from the campus network. Because of the limitation of transferring data at Gbps rates, recent work has focused on numerical simulation and prototypes at lower rates [11]. Purposed-built high speed end devices (e.g., DTNs) transferring data across the Science DMZ via high-speed switches will permit the creation of a test-bed for the proposed multi-IPS scheme testing and support research in networking and security [11-19]. His students are supported by NSF SSTEM Award 1259993.

2.3 [redacted] (Mathematics/Engineering; Comp. Fluid Dynamics, Parallel Programming)

[redacted] is the Chair of the Mathematics and Science Department. He actively collaborates with the College of Engineering and Technology by mentoring engineering students in research projects involving computational fluid dynamics and parallel programming. After having worked at Los Alamos National Laboratory for ten years where he modeled surface tension and flow inside an internal combustion engine, [redacted] has continued his investigations into fluid dynamics at Northern. He was awarded an Army High Performance Computing Research Center (AHPCRC) grant to work with undergraduate engineering students, and developed a software library to solve the incompressible and compressible Navier-Stokes equations in simple geometries, using finite difference approximation.

Computational fluid dynamics relies on the solution of a coupled set of partial differential equations called the Navier-Stokes equations. Fig. 4 shows a 3D modeled convection simulation. A typical 3D convection simulation requires 100^3 coordinates for each of the 20 variables (velocity, temperature, pressure, internal energy, density, etc.). Simulations run for at least 10000 time steps. Using Matlab's 8-byte double precision, the amount of data for a single simulation is 1.6 TBs. The calculations run on Northern's parallel supercomputer, Aguila [20], which is currently accessed via the campus network.

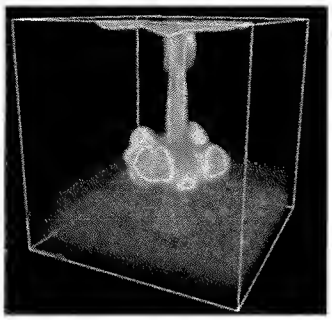

Fig. 4. 3D convection modeled by a finite difference approximation.

The supercomputer hosts an 18 processor, 108-core Linux based computer cluster funded by the same AHPCRC Grant. Transferring 1.6 TBs from Aguila to storage nodes and lab stations at the current CEN rate (100 Mbps) takes more than 20 hours. The same data transfer through the proposed research network would require 13 minutes. Thus, expected outcomes of improving the intra-campus capacity include faster and more accurate fluid dynamic simulations by removing transfer rate limitations and increasing simulation time steps. [redacted] students are supported by the NSF New Mexico Alliance for Minority Participation (NSF NM-AMP HRD 1305011) grant [21], a statewide collaborative effort between several institutions, including New Mexico State University and Northern, in which he serves as Co-PI. He and his students have been recognized in state competitions [22], and have published in professional journals in the area of mathematical optimization applied to solar energy, and in collaboration with [redacted] have developed linear programs to optimize the use of energy [9].

2.4 Institutional - Engineering Education for Undergraduate Research

More than 93% of Northern's incoming students test into developmental math, and the main student feeder high school's ranking is 3/10 [23], where 10 is the highest score. Most engineering students require one year of algebra and trigonometry before they are ready for calculus, the pre-requisite to engineering courses. The need for one or two remediation years was the primary cause of attrition prior to 2011.

Mathematical Education: Since 2011, the College of Engineering and Technology has established "The Wright State Model [24]," introduced to Northern by [redacted] and later replicated by UNM. [redacted] work in this area has been published in the American Society of Engineering Education (ASEE) [25]. This model permits students to advance through math and engineering in parallel, in contrast with the serial math-engineering sequence. At the same time, students are able to take hands-on introductory level courses covering the technical pillars of the program. This removes the calculus bottleneck by providing students with the key mathematical tools they need for introductory and intermediate level courses. For example, historically a student taking circuit analysis was required to have passed Calculus I, Calculus II, and Differential Equations. Rather than requiring this sequence, the course Introduction to Math and the Summer Accelerator program at Northern provide students with just the fundamental knowledge required for engineering courses. With this background, students are able to take engineering courses and continue a deeper math preparation in parallel (Fig. 5). This aggressive hands-on approach engages students and provides further incentives for advancing in the math sequence.

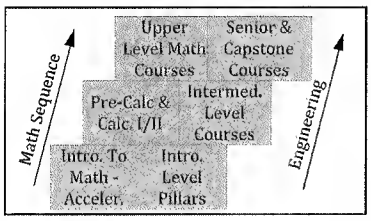

Fig. 5. Parallel math-engineering educational approach.

Hands-on Undergraduate Research: The pillars of the IET program are: Programming, Web, Human-Computer Interaction, Databases, and Networking [26]. Removing the calculus bottleneck permits the introduction to the pillars much earlier during the program. This allows students to engage in introductory research activities through hands-on "learning-by-doing" during intermediate level courses (see Fig. 5). By the time they reach Capstone and senior level courses, students already have a considerable hands-on expertise and a complete mathematical background to engage in more advanced research experiences. Consider the Networking pillar shown in Fig. 6, which illustrates the pre-requisites (more than 45 credits,

including upper level math, software design, and computer architecture) required to take the course Introduction to Networking in a traditional program (this specific case was taken from a program in another university in NM). In contrast to Fig. 6, Northern's "learning-by-doing" approach exposes students to the pillars during their freshman year, engaging them with real life hands-on experiences. The development of research ideas is thus more fluent during their senior year. The IET model of education was presented in the 2012 Annual ASEE Conference [27]. Similar courses are now being offered at other institutions (e.g., "Networks Illustrated: Principles without Calculus" [28], Princeton University, 2013).

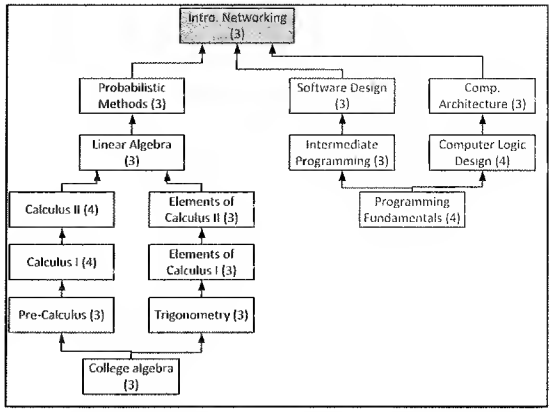

Fig. 6. Typical pre-requisites for an introductory course in networking in a traditional program. In contrast, Northern's IET program introduces students to the pillars of IET during the freshman year (see Fig. 5, Intro. Level Pillars).

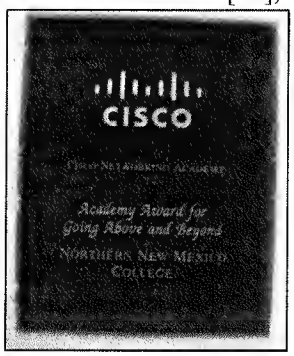

Fig. 7. Northern's recognition by Cisco for going "Above and Beyond," among more than 2,000 institutions from US and Canada.

Cisco, at its headquarters in Silicon Valley, recognized Northern in 2013 for going "Above and Beyond" in contributing to networking education [27, 29] (see Fig. 7). IET undergraduate students continuously conduct research in the area of linear optimization applied to MPLS network, security, and routing, publishing their work in journals, IEEE, and NSF sponsored conferences and workshops during their undergraduate coursework [14, 30].

In 2014, Northern became the only institution in northern New Mexico, and the first non-PhD granting institution in the state, to offer an ABET accredited program – its IET program. This CC*DNI project would permit the expansion of Northern's "learning-by-doing" model through remote experiment control (REC), in collaboration with high schools (via dual-credit "hands-on" research) and community colleges (see Section 2.12). This initiative will be disseminated through one of the largest STEM communities, Cisco Academy [31] (2,000+ institutions in the US and Canada).

2.5 [redacted] (Biology; Plant Genomics)

[redacted] Cell Nucleus Laboratory and collaborators use a combination of genetic, cellular, and genomic approaches to fully understand the relationship between nuclear structure and function in eukaryotes. With support from the NIH/NM-Idea Networks for Biomedical Research Excellence (INBRE) P20GM103451 and from NSF New Mexico Alliance for Minority Participation (NSF NM-AMP HRD 1305011), his lab is using NextGen sequencing to study the interaction between Cajal bodies (CBs) and the telomerase RNP at the organismal level [32]. Recently, [redacted] and [redacted] (Co-PI of this CC*DNI project) have also received a Pilot award from the National Center for Genome Resources (NCGR) [33] to initiate a collaborative research project in next-generation sequencing, which requires the use of modern tools such as Illumina RNA-seq to dissect the genomic expression profiles of multiple mutants. Located in Santa Fe (see Fig. 8), NCGR is supporting this project and collaborating with Northern by producing Terabytes (TBs) of sequencing, ready for analysis at Izaguirre-Sierra's lab. Sequencing collaboration with NCGR

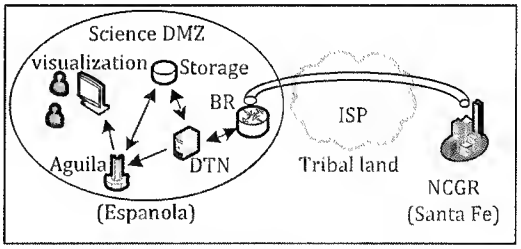

Fig. 8. [redacted] lab collaborates with NCGR [33], which produces TBs of DNA genome sequencing. Upgrading Northern's border router would facilitate the deployment of a 30-mile fat pipe suitable for transferring DNA data. High-speed intra-campus would permit 10 Gbps transfers among DTN, storage nodes, Aguila supercomputer, and visualization stations.

helps to understand the role of CBs in the biogenesis of non-coding ribonucleic acids (RNAs) in land plants (Arabidopsis and Physcomitrella). Because of the nature of the research –DNA/RNA data in the order of TBs– the Northern/NCGR collaboration is currently limited to manual transportation of sequencing from NCGR to Northern. Vertical integration to ABQG via Santa Fe (see Fig. 1) would provide high-speed connectivity to collaborators such as NCGR and to out-of-state institutions such as The Shippen lab at Texas A&M [34]. Additionally, the intra-campus integration of DTNs, storage nodes, and labs would speed up bioinformatics computation via faster data transfer from storage nodes to Northern's Aguila supercomputer [20]. In 2014, [redacted] was invited to present his work at The Max Planck Institute of Molecular Cell Biology and Genetics in Dresden [35]. A more dynamic collaboration with The Max Planck Institute is another goal that this project could achieve.

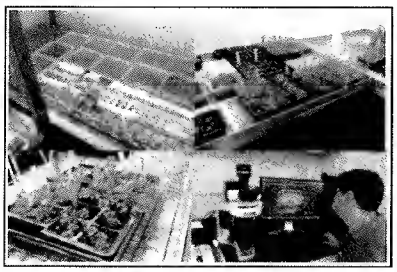

Fig. 9. Izaguirre-Sierra's Cell Nucleus Lab. Lower right corner: visualization station.

2.6 [redacted] (Environmental Science; Genomics, Bioinformatics, Neuroecology); Co-PI

[redacted] lab investigates the evolutionary responses to novel environmental change in Sceloporus lizards [36-38] (AKA Spiny lizards or Swifts) and Corvid birds (social species such as crows), focusing on their genetic and plastic responses to environmental change and the underlying interactions between physiological (hormonal), behavioral (resource use and niche construction), and epigenetic mechanisms. He and his collaborators are currently examining the genomes and epigenomes of lizard populations (with NextGen Seq funding from NIH/NCGR NM-INBRE, NCGR Pilot Award, and students funded by NSF New Mexico Alliance for Minority Participation NSF NM-AMP HRD 1305011), to ultimately associate phenotypic responses (morphological and behavioral) to invasive species with underlying genetic variation and expression (evolutionary and lifetime responses). Because many of the adaptive responses are behavioral, the lab is also interested in examining associated biomechanics, ecophysiology, and neurology using high-speed video and neurological assessment. Genomics data sets and high-speed video outputs (e.g., QUAST and ProAnalyst) are extremely large (5-50 TBs), which require high intra-campus capacity to transfer the sets from storage nodes to the labs. For a small data set of 5 TBs, the transmission time in the current CEN network operating at 100 Mbps is more than 100 hours (without considering protocol overhead). The same data transfer across the proposed research network at 10 Gbps would take approximately one hour. [redacted] lab is also investigating the evolutionary significance of the Social Brain Hypothesis [39] by examining social bird species. This research requires comparing brain sizes specifically to social cognitive function through simulating social interactions in the lab while measuring brain activity using fMRI techniques and brain size using MRI [40]. Large data sets (0.5-7 TBs) are involved in the analyses of both MRI techniques (e.g. with Amira 3D Software) and social networks (e.g. with UCINET, NetDraw). Prior to joining Northern, [redacted] was with the Biology Department at Pennsylvania State University (PSU), where fMRI data is generated. The integration of Northern's network with national and regional networks would permit a more efficient data transfer from PSU for data analysis, and thus would significantly improve the efficiency of [redacted] lab research.

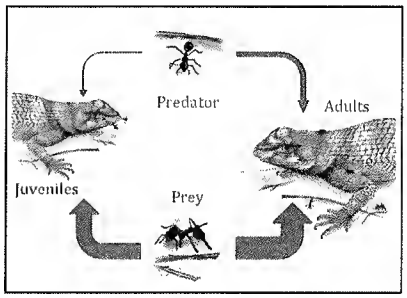

Fig. 10. Fire ants act as predator and prey for fence lizards imposing greater bottom-up effects (thickness of arrows) than top-down. Lizards respond through endocrinological, epigenetic, morphological, and behavioral means.

2.7 [redacted] (Biology; Neurobiology, Ecophysiology)

[redacted] is a pioneer in New Mexico in the use of low-cost electrophysiological equipment such as SpikerBox [41] or home built amplifiers and open source data recording systems (Spike Hound, Audacity), which allow the recording of electrophysiological data using the sound card of a personal computer. Such recording systems gather complex data that are further processed with excellent results

despite the low cost. In contrast with traditional theoretical educational models, the research by [redacted] lab is used for active learning hands-on projects in the form of workshops utilizing cockroaches, crickets, and grasshoppers (see Fig. 11). [redacted] Invertebrate Biological Lab specializes in analyzing data recorded from neural activity [42, 43], mostly in invertebrate models.

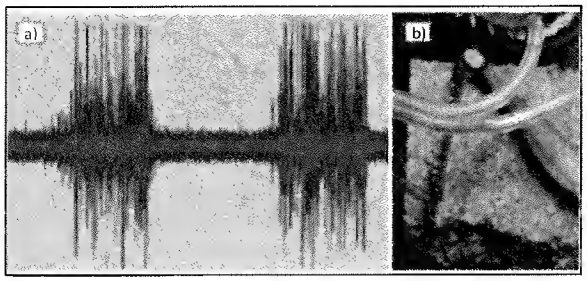

Fig. 11. Delivery of an air puff elicits a burst of action potentials (a) in grasshopper appendage (b).

Research plans, supported by NSF S-STEM DUE-0806469, NSF-ROA EAGER IOS-1249546, and NSF-ROA I3 EAGER IOS 1249546, include the recording of action potentials triggered by mechanoreceptors in cockroach appendages. Once the neural recordings are performed, data is transmitted from the neurobiology laboratory to visualization stations that use Lab-View and Matlab. As required for high-resolution analysis, a high-capacity cyberinfrastructure would facilitate the transfer of data generated by examining the biomechanics and neurological signals of invertebrates to work stations and data repository. High-resolution video frames result in large data collection (20-50 TBs) that currently cannot be transferred efficiently on campus.

2.8 [redacted] (Chemistry; Agricultural Science)

[redacted] group is currently supported by NSF NM-AMP HRD 1305011 to investigate the composition of the water used by local farmers in the Española Valley. Farmers in this area have been using the water from the "acequias" system for centuries. The acequias are water canals engineered in northern New Mexico historically by Native American tribes, and later used by the first Spanish settlers. Acequias divert waters for agricultural purposes into pockets of otherwise arid land. As biological canals, acequias are essential for soil and water conservation, wildlife and plant habitats.

[redacted] lab is investigating the chemical composition of these acequias. The studies include monitoring levels of alkalinity, metals, and organic pollutants present in the water and comparing them with regional water quality standards. A focus of this research is how the water quality changes throughout these acequias and effects locally grown crops (e.g., garlic, carrots, and others), including those grown at Northern New Mexico College's Sostenga Farm and used at the main campus' cafeteria. Monitoring temporal and spatial change in water quality of acequias and bioaccumulation of pollutants in crops will allow the quick responses necessary for proper management of the acequia system should pollutants begin to approach unsafe levels. This is an important first line of defense relied upon by the local agricultural communities. Long-term monitoring data sets are stored in a localized database that can be accessed by students and community through the campus network.

2.9 [redacted] (Env. Science; Landscape Ecological Modeling, Simulation, GIS)

[redacted] research focuses on the environmental processes that impact community ecology from local and regional landscape scales and how stochastic events drive these processes in response to climate change. Ongoing research on Montezuma quail population dynamics [44 - 46] is an example of this -utilizing actual species distributions from radio-telemetry to compare to existing and predictive models (Gap Analysis) at local and regional scales.

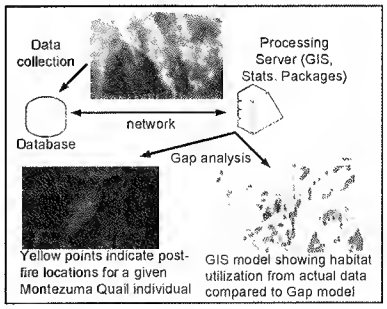

Fig. 12. GIS information flow and habitat data analysis.

Distribution models for this species are assessed from long-term data collected through the help of undergraduate research assistants at Northern. Many of these undergraduates are funded through the NM-AMP NSF HRD 1305011. Future potential research projects involving modeling in the GIS environment include assessing the distribution of macro-invertebrates in response to droughts and flood regimes, brown bear range and

habitat use in northern New Mexico, and understanding the impact of climate change on sky islands by examining dusky grouse (Dendragapus obscurus) range and habitat use. Much of this research will include the use of wireless telemetry and advanced GPS equipment with data-loggers (e.g., Trimble) to collect information from hard-to-reach remote locations. Habitat models constructed in the GIS environment (ESRI ArcGIS) require substantial resources for processing data and storing large datasets and high-resolution imagery (0.5-5 TBs). Thus, the research depends on high-speed data transfer and access to servers for storage and data analysis.

2.10 [redacted] (Mathematics; Numerical Modeling)

[redacted] spent almost ten years as a researcher at Los Alamos National Laboratories before joining Northern in 2009. There, she worked in numerical modeling and subsurface imaging of the earth by both electromagnetic and seismic methods. Her work includes algorithms for inverting magnetotelluric (MT) data in the presence of bathymetry or topography, based on finite-difference (FD) approximations that permit sloping discrete boundaries inside model elements [47]. FD algorithms for MT data require large storage (TBs) and high-speed data transfer to Northern's supercomputer [20], which are severely limited by the current fast-Ethernet network capacity.

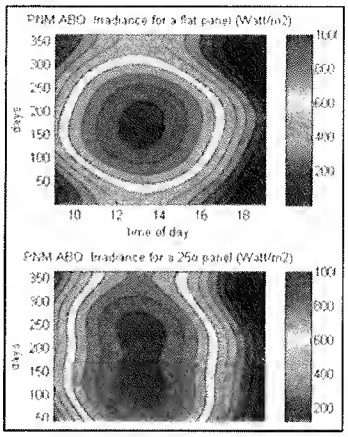

Fig. 13. Irradiance at PNM's Albuquerque site [7].

[redacted] and her undergraduate students are supported by NSF NM AMP (HRD 1305011) [21] and a Los Alamos National Lab Foundation Grant to also design predictive models for seasonal pollen release in the atmosphere in Los Alamos/Española [48] and to analyze the irradiance in Albuquerque (see Fig. 13).

2.11 Science Undergraduate Education – Initiative for Next-Generation Sequence Analysis

Northern's science programs have recently incorporated next-generation sequencing (NGS) technology and data analysis in the classroom and in undergraduate research. Historically, students at small institutions such as Northern have not had access to NGS datasets because of the size bottleneck of those sets (tens/hundreds of TBs) and the cost of experiments. To overcome this barrier, Dr. Izaguirre-Sierra has partnered with Cold Spring Harbor Laboratory (CSHL, New York) [49] and the National Center for Genome Resources (NCGR, see Section 2.4) [33]. Beginning in the summer of 2015 and through the NSF project "Infrastructure and Training to Bring Next Generation Sequence (NGS) into Undergraduate Education," Northern will have access to CSHL's RNA eukaryotic datasets. Northern's connection to ABQG exchange point is essential for data sets to be transferred, since transfers of TBs of data at the current 100 Mbps rate are not practical (e.g., even assuming no overhead and full campus bandwidth allocated to a single data transfer, a representative RNA file of, say 10 TBs, would take more than 200 hours). Similarly, Northern faculty periodically drive 30 miles from Northern's Espanola campus to Santa Fe to obtain datasets of DNA/RNA sequences from NCGR's offices (see Fig. 8). Using DNA/RNA datasets, students will be investigating high-throughput RNA-sequencing. This will complement the already active learning approach using invertebrate species for which Northern was nationally recognized by the Society for the Advancement of Chicanos and Native American Scientists (SACNAS) [2]. This educational model (see Fig. 14) enables early "reward" (hands-on research) that provides additional motivation to advance through the curriculum core in parallel to research activities. Integrating Northern to high-speed regional (NCGR - Santa Fe) and national (CSHL - New York via ABQG) networks would grant access to faculty and students to large DNA/RNA datasets that are otherwise currently non-viable (CSHL data) or are non-efficiently transferred (NCGR - driving 30 miles to obtain data). The datasets are essential for all students in biology,

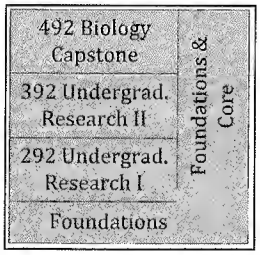

Fig. 14. Building blocks of the Biology program. Starting at the sophomore level, students perform high-throughput RNA-seq experiments while advancing in parallel through the core of the curriculum.

environmental science, and chemistry, who are required to have the undergraduate research experiences shown in Fig 14.

2.12 Additional Impact on Remote Experiment Control and Collaboration

Northern New Mexican students have their roots in the small Hispanic villages high in the Jemez and Sangre de Cristo Mountains, where descendants of 17th century Spanish settlers still live as small farmers and artisans. Historically, access to these remote villages during the winter season has been a challenge for students to attend classes, continue their research, and prepare for exams. An advantage of the research network, which will permit Northern to address this characteristic challenge for students, will be the facilitation of remote access control (REC) to lab equipment -some of which require low latency- to be connected to the network. The first lab to adopt REC capability will be the networking lab directed by the PI, [redacted]. As illustrated in Section 2.2, [redacted] areas of interest include network optimization [11-19]. Lab experiments include data transfers (e.g., testing of routing schemes [14] and IPS inspection strategies [11]), which will be conducted remotely. The following features will be implemented:

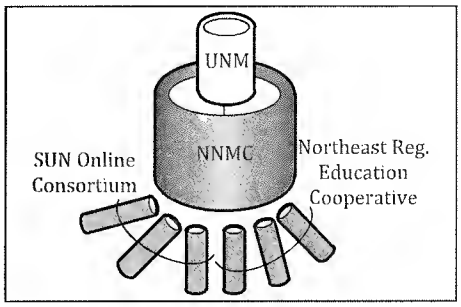

Fig. 15. Northeast Regional Education Cooperative (NEREC) [51] is an organization in north-east NM that provides services to six public school districts - high-schools (HSs). SUN Online Consortium [50] is composed of community colleges (CCs) and 4-year institutions. The New Mexican pipeline from HSs to 2-year (CCs) to 4-year (NNMC) to PhD-granting institution (UNM) will be reinforced.

- Scheduling scheme to permit researchers or students to reserve lab equipment in advance;
- Access control based on ACL and authentication based on researcher / student credentials.

By implementing REC, Northern will also expand its collaboration with other institutions by developing new courses and undergraduate research experiences. This would have a broad impact in the region in terms of career pipeline (see Fig. 15), since Northern is part of the New Mexico's Skill Up Network (SUN Online) [50]. Funded by the Department of Labor's Trade Adjustment Assistance Community College and Career Training grant, SUN Online is a consortium of eleven state institutions (community colleges and universities) sharing quality material to ensure that students have access to a variety of resources that strengthen degree programs. The REC capability will also be available to Northern's partner, the Northeast Regional Education Cooperative (NEREC) [51]. NEREC serves six districts in Northeast NM. Northern and NEREC have agreed to create a career pipeline by which some pillar courses in the IET program (see Fig. 5) are taken at high-schools (HSs). Other collaborators that recently signed articulation agreements for resource and curriculum sharing with Northern include Southwestern Indian Polytechnic Institute in Albuquerque and the Eastern New Mexico University branch in Ruidoso, NM.

3. Project Implementation

3.1 Existing Network Infrastructure

The current campus enterprise network (CEN) is a hierarchical small-size network (see Fig. 16). The CEN is attached to a regional ISP via a Cisco 2800 Integrated Service Router (ISR). Northern gains access to the Internet and metro- and regional-networks through a 100 Mbps connection provided by the ISP. Traffic entering the CEN is subject to deep packet inspection by a firewall and forwarded to a collapsed core-distribution layer composed of five stackable Cisco 3750 layer 3 switches that operate as a single unit. Northern's motivation for the two-tier hierarchical network with collapsed core/distribution

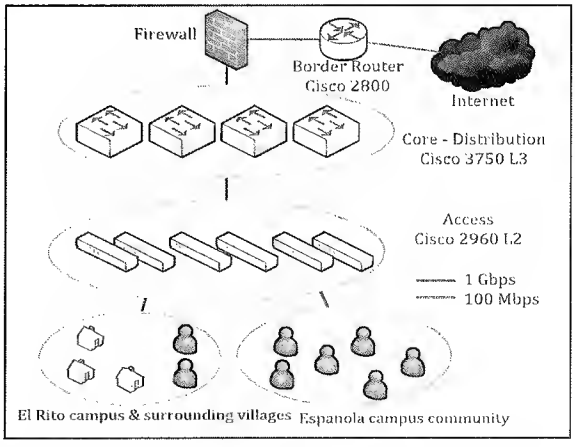

Fig. 16. Current Campus Enterprise Network (CEN).

layers was the small-size campus community (at most, ~600 people at a time) observed in the past.

While the original CEN design is still viable for regular campus traffic, since the inception of the Bachelor's of Engineering, Biology, and Environmental Science degrees in 2008, the research projects in which new faculty are involved (as described in Section 2) require an enhanced throughput capacity, beyond the Fast Ethernet rate (100 Mbps) currently available. Moreover, the increasing collaboration with metro, regional, and national partners demand further improvement and connectivity to Internet2. The CEN also provides connectivity to Northern's El Rito campus, which hosts approximately 50 students and staff. El Rito serves as a hub for numerous isolated mountain villages, many of them without Internet services. Northern provides Internet services and professional development to the regional population.

3.2 Proposed Science DMZ

Northern will create a dedicated Science DMZ to support undergraduate research and education in science and engineering (see Fig. 17). Northern's IT department will deploy and install a fiber/switch network dedicated for the research community. The complete technical design of the Science DMZ (e.g., DTN, switch, and border router models) is deferred to the end of the first year and will be finalized by month 12 of the project (see Table 3). The critical performance requirements informed by the research described in the prior section, drives this augmentation to the College's infrastructure. The dedicated network will provide at least 10 Gbps connectivity to the following five access locations: datacenter, which will host storage nodes and the new DTNs to be used by researchers across campus; networking / engineering lab (see Section 2.2); two science labs (see Sections 2.5 - 2.9); and Aguila supercomputer (see Sections 2.3, 2.5, and 2.10). The plan will:

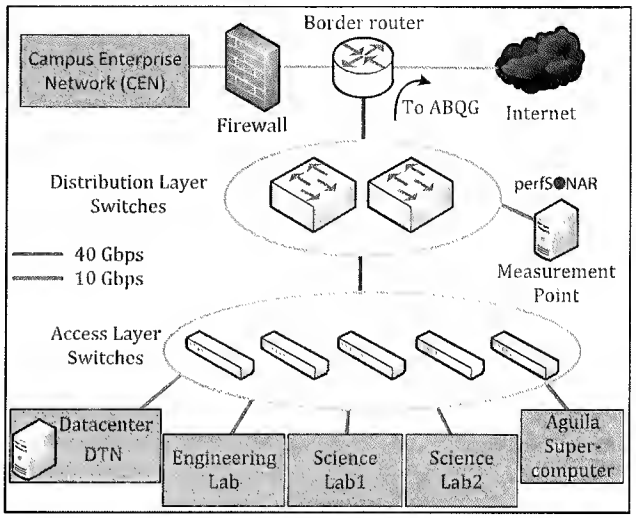

Fig. 17. Proposed Science DMZ.

- Purchase five access layer switches to install in the five locations specified above. These switches will serve as the access layer for end devices. They will implement Link Aggregation Control Protocol or EtherChannel for link aggregation to form 10/40 Gbps connections to distribution switches. A potential access layer switch is the Cisco Nexus 3172PQ.
- Purchase two distribution layer switches. The five access layer switches will uplink to the aggregation switches via 10/40 Gbps connections. The two aggregation switches will uplink to a border router to be purchased. A potential distribution layer switch is the Cisco Nexus 9396PX.
- Purchase and install a border router to replace the current border router. The router will separate the CEN and the Science DMZ into two different zones. Traffic addressed to the Science DMZ will be subject to ACL rules at the border router to verify IPs and ports without any additional inspection at upper layers. Virtual Router / Forwarding (VRF) could be used to segregate Internet and (future) Internet2 traffic. A tentative border router includes a Cisco ASR 9000 family device.
- Implement measurement points with perfSONAR [5] and Netflow [6] to quantify intra- and inter-campus performance, and to collect traffic information to be used for future upgrades.
- Implement an online scheduler and associate access control in the border router for REC (see Section 2.12) to allow researchers and students reserve lab equipment and use it remotely.

3.3 Future Network Expansion

To satisfy the needs of increasing collaboration with regional and national institutions, Northern will require further improvement and connectivity to Internet2. The first step toward obtaining connectivity to Internet2 is the acquisition of the new border router through this CC*DNI project. The new border router

will contain multiple built-in interfaces of at least 10 Gbps ports, and will support expansion slots for ports of 40 Gbps or above.

The following step will be the bandwidth upgrade and connectivity from Northern's Española campus to ABQG exchange point (see Fig. 1). The prohibitive high bandwidth cost and limited connectivity across the mountainous sovereign tribal lands, sparsely populated (17 people per square mile versus the national average of 87), with varying governing bodies, represent challenges for the connectivity upgrade. The college is actively working with a consortium of universities and state agencies (see letters of commitment from the two largest research institutions in the state), led by UNM, to leverage costs of initial last-mile builds in the interest of the broader Española community. Northern expects to increase its bandwidth connectivity to its ISP (and to Albuquerque) to 1 Gbps in the near future.

3.4 Project Plan, Goal, and Milestones

The goal of this projeet is to improve Northern's current network infrastructure to better enable data-intensive research and education projects. Table 3 summarizes the schedule for the key tasks and milestones of this 24-month project. The PI and co-PIs will coordinate with UNM's IT department to determine exact dates for tasks listed in Table 3. UNM's IT department will provide support in the variety of tasks associated with the technical design and performance testing. The PI and Co-PIs will meet (either virtually or face-to-face) once per month with UNM's IT during the first six months of the project, which will require more technical support from UNM for the improvement of the initial network design, and every two months thereafter to finalize the network design. In addition, NMSU will provide technical mentorship and coordinate efforts with other research institutions in support of Northern's cyberinfrastructure implementations. Upon successful completion of the first annual report, equipment will be ordered and installed.

Table 3. Schedule of key proposal implementation tasks. Numbers 1-24 indicate months.

Task	1	1-6	7-12	12	13	14-15	16-18	19-24
Task 1: Initial meeting with researchers and UNM (partner institution)	X							
Task 2: Incorporate improvements to initial network design given in Section 3.2, based on UNM's Science DMZ feedback		X						
Task 3: Select fibers for each switch connection; select switch and border router models; determine DTN specifications			X					
Task 4: Submit annual report				X				
Task 5: Coordinate procurement process					X			
Task 6: Determine date for installation of router, DTNs, switches, and fibers					X			
Task 7: Receive border router and configure routing plan, ACLs, Netflow						X		
Task 8: Receive switches and configure for each location						X		
Task 9: Deploy measurement point and install Netflow and perfSONAR							X	
Task 10: Schedule of automatic, regular performance report							X	
Task 11: Implement pilot remote access control feature for the Networking lab (see Section 2.12)							X	
Task 12: Conduct testing and gather data								X
Task 13: Disseminate resource sharing (pilot remote access control lab) to SUN Online and NEREC Consortiums (see Section 2.12)								X
Task 14: Summarize and report performance data								X

4. Broader Impacts

All researchers participating in this project are from a minority group. The PI and one Co-PI are Hispanic, and the remaining Co-PI is Native American. All senior personnel listed in Table 2 are Hispanic, as well

as the entire IT department that will deploy the network. This mirrors the 72% Hispanic and 11% Native American student population at the college. Although the "world is becoming flat [52]," the isolated villages of northern New Mexico and NNMC still face the challenges articulated by [redacted] president of the Hispanic Association of Colleges and Universities (HACU):

> *Even in today's tough labor market, jobs in high-demand fields such as engineering, science, technology and education remained unfilled. Hispanics make up the fastest growing component of our labor force, yet because they lack advanced degrees, they are effectively barred from entering professions critical to our nation's economic strength and security. It is imperative that we close this education gap.*

Until recently, access to STEM four-year degrees for New Mexicans required them to leave the region, as Engineering, Biology, and Environmental Science programs were only recently created. This CC*DNI project represents the next step for Northern in continuing its path towards the "flat word" and in closing the education gap for minority populations. The proposed infrastructure upgrade will move Northern forward toward the vertical integration to regional networks, which is essential to increase the effectiveness of moving Terabytes of data on station wagon-type of transfers to moving data on operationally efficient high-speed connections to partners in the main cities in New Mexico, including the National Center for Genome Resources, the University of New Mexico, and others. The upgrades will reinforce the growing undergraduate research activities with national partners such as Texas A&M, Pennsylvania State University, and the University of South Florida, with which transfers of large datasets will be enabled under projects such as NSF's "Infrastructure and Training to Bring Next Generation Sequence (NGS) into Undergraduate Education." The new Science DMZ will allow intra-campus integration of DTNs, storage nodes, labs, and Northern's Aguila supercomputer, facilitating high-speed data transfers among them. By implementing remote experiment control features to lab equipment, this project will help to address the geographical challenge of campus access experienced by students living in remote mountain villages, especially during winter months. Northern will develop remote undergraduate research experiences without compromising the hands-on activities known to be essential for minority populations studying STEM. These unique features will be shared with key state partners: the Northeast Regional Education Cooperative (NEREC) of high-schools, the New Mexico's Skill Up Network (SUN Online) of community colleges, and UNM and NMSU, the two main research institution in New Mexico. By becoming the STEM bridge for northern-central New Mexico, Northern will strengthen the STEM higher education pipeline.

5. Results From Prior NSF Support

5.1 Grant EPS 1005886

Collaborative Grant C2: Improving Broadband Connectivity for Tribal and Regional Colleges in New Mexico. Leading institution: University of New Mexico (UNM). Sub-awardees: Northern New Mexico College, Navajo Technical College, and Western New Mexico University.
Amount: $ 1,176,470 (Northern: $ 250,000). Publications: No publications produced under this award.
Period: September 1, 2010, to August 31, 2012. Sub-recipient (Northern) PI: [redacted]
Summary: the C2 EPSCoR grant funded the upgrades in the Campus Enterprise Network (CEN) shown in Fig. 16. Northern purchased and installed five Layer 3 Cisco 3750 switches that operate at the core-distribution layer. Fiber optic connections across campus were deployed, thus establishing uplink connections from access layer switches to the core-distribution layer. Besides connections from the core-distribution to the current buildings, additional fiber optic connections were deployed to the new buildings at the time: Teacher Education, Solar Energy Research Park and Academy (SERPA) (which hosts the College of Engineering and Technology), and the new library. The access layer switches were upgraded to Layer 2 Cisco 2960 switches, which provide connectivity to end devices at 100 Mbps. As a result of the C2 EPSCoR project, Northern's access to the Internet increased from 6 Mbps to 100 Mbps. This facilitated an increase in the delivery of hybrid and online courses, which were limited before this project. In Fall 2014, 788 students were enrolled in web-based or hybrid online courses. Considering the

size of the college, approximately 1,500 students, this indicates that about 50% of them use online education. The C2 grant also funded the new wireless network that is currently in use and has 100% campus coverage. Prior to 2010, Northern did not have a campus-wide wireless network, and connectivity to the Internet was not available from classrooms and laboratories.

5.2 Grant DUE [redacted]

Biological Sciences S-STEM Project at NNMC

Total amount: $ 598,000. Publications: No publications produced under this award.
Period: August 1, 2008, to December 31, 2013. PI: [redacted]

Summary: Results from this project show that merit- and need-based scholarships have a direct impact on recruitment, retention and graduation rates. Fig. 18 illustrates how the award contributed to a more than 15-fold increase in recruitment over five years and an 86% retention rate. Of the 21 graduates in Biology and Environmental Science up to 2013 (when this was reported), over 40% graduated Cum Laude or Magna Cum Laude, 100% were underrepresented ethnic minorities, and 65% were women. Fig. 18 demonstrates an increase in the number of students declaring Biology majors between 2008 and 2012.

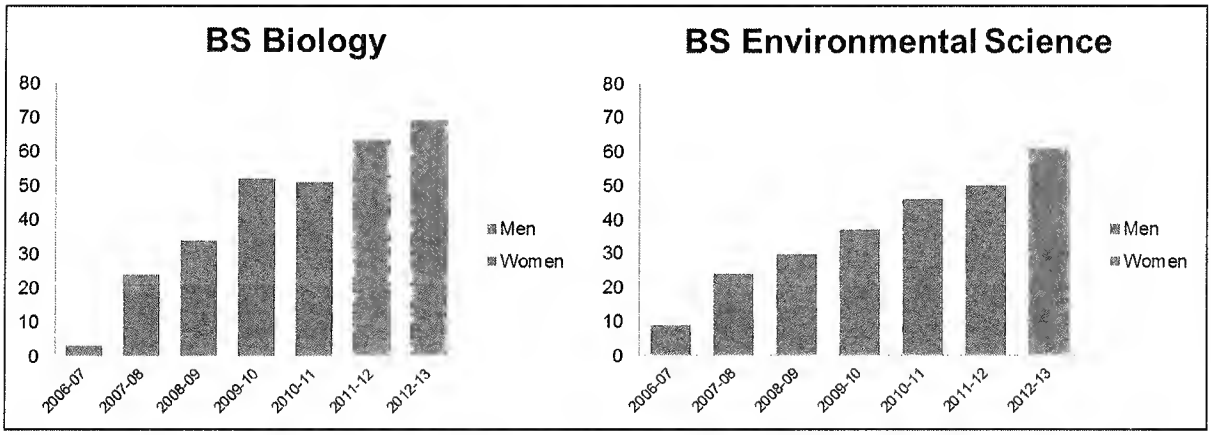

Fig. 18. Annual number of students declaring majors in Biology (left), and Environmental Science (right) between 2006 (then associate degree only) and 2013.

As the second half of the panel illustrates, the Environmental Science program has grown steadily between 2008 and 2012, while Biology began to spike upward as the scholarships began drawing students. The enrollment in both Biology and Environmental Science has been sustained. The enrollments during the last academic year (2013/2014) were 77 (Biology) and 75 (Environmental Science).

5.3 Grant DUE [redacted]

Pathways for Engineering: Access to Resources for Learning (PEARL)

Total amount: $ 621,708. Publications: No publications produced under this award. Period: October 1, 2013, to September 30, 2018. PI: [redacted]

Summary: This program seeks to increase the number of underrepresented minorities in engineering through scholarships, mentorships, and comprehensive support services that aim to increase retention and graduation rates among recipients. By giving students an opportunity to become involved in research projects and enhancing critical

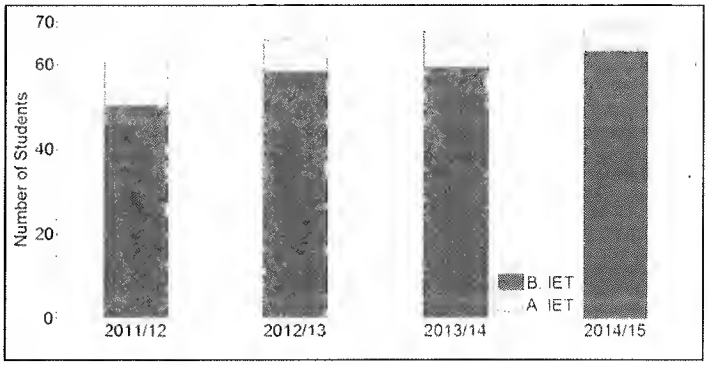

Fig. 19. Enrollment, bachelor (green) and associate (yellow) degrees in Information Engineering Technology (IET).

thinking skills, students will learn the process of scientific inquiry, necessary for graduate school. Fig. 19 illustrates the trend of the number of students enrolled in the bachelor in IET (green) and associate in IET (yellow). As a growth reference, the number of students in the bachelor degree in IET has always increased since the inception of the program in 2008. In 2011/12, there were 50 students enrolled in the bachelor degree, while in 2014/15, there were 63. This represents 26% growth in a 3-year period. With the support of the PEARL grant, it is expected that the number of IET students within the following 3-year period (2015/2016 to 2018/2019) will increase at least 35%, to 85 students declared in the bachelor degree. The overall number of students, associate and bachelor combined, is approximately 70 (2014/2015). By 2018/2019, the expected number of students is 95. PEARL also supports the Mechanical Engineering (ME) program, which currently has 30 declared majors.

5.4 Grant DUE [redacted]

ASPIRe - Advancing STEM Performance, Innovation and Retention

Total amount: $ 499,252. Publications: please refer to [25, 53].

Period: June 15, 2008, to May 31, 2014. PI: [redacted]

Summary: This STEP grant program focused on recruitment and retention. Successful initiatives of this grant have been institutionalized, including Dual Credit with local high schools and the "Math Accelerator Program," a summer math enrichment program that was taught in the College of Engineering and Technology as a pilot for three years and has now been institutionalized as the course ENGR 115. These activities, along with tutoring in a variety of STEM fields, and STEM seminars with invited scholars, addressed many of the larger academic issues that Northern students face. Results from this STEP program for all future programs to learn from is that students who complete the first year are 87% more likely to graduate. By the end of the 2014 academic year, Northern's ASPIRe services had been offered to approximately 300 students. The demographic distribution for participating students was approximately 83% Hispanic, 5% Native American, 2% African American and 10% White. Of those students, approximately 46% were female and 54% male. In this regard, these two ASPIRe programs contributed to national efforts to increase participation of minorities and women in STEM.

The main activities of ASPIRe were designed to: 1) prepare concurrently enrolled high school students for college-level conceptual analysis, critical thinking, problem solving, and to convey the value of experimental replication; 2) recruit college freshmen and sophomores with undeclared majors to STEM programs of study by assisting them in career planning using seminars, field trips, and exposure to successful STEM scientist and engineers; (3) supplement college STEM curricula with support services including counseling, mentoring, and tutoring for students at risk in STEM courses; and 4) instill a love of learning in intellectually challenging STEM fields by sponsoring practice-oriented research projects in summer programs at Northern. First Year Experience activities were very successful in exposing freshmen students to hands-on activities in the field. These activities are not traditionally available to students until their junior or senior year. After tracking participating students for at least three semesters, the retention rate was 76%. This is very high compared to a 50% rate of first year students. Moreover, in Fall 2013, the First Year Experiences for engineering students showed a one-semester retention of 94% for participants. The main successful activities of the grant, the Math Accelerator Program and the First Year Experience, have been institutionalized at Northern and the activities have continued regardless of the expiration of the grant. A comparison of the three main activities of ASPIRe, in terms of students who participated in each and were retained, graduated or dropped, is shown in Fig. 20.

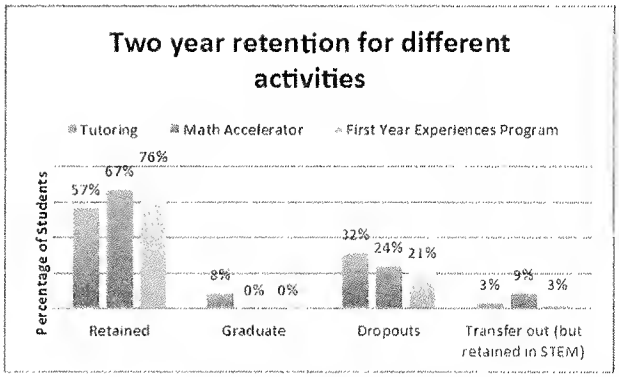

Fig. 20. ASPIRe retention results.

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SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION	FOR NSF USE ONLY		
Northern New Mexico College	PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR [redacted]	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. [redacted]	0.00	0.00	1.00	[redacted]	
2. [redacted]	0.00	0.00	1.00	[redacted]	
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	**11,925**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**11,925**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**3,936**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**15,861**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				**3,383**	
2. INTERNATIONAL				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**0**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**0**	
TOTAL OTHER DIRECT COSTS				**0**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**19,244**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **(Rate: , Base:)**					
TOTAL INDIRECT COSTS (F&A)				**0**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**19,244**	
K. SMALL BUSINESS FEE				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**19,244**	

M. COST SHARING PROPOSED LEVEL $ **0** | AGREED LEVEL IF DIFFERENT $

PI/PD NAME [redacted]

ORG. REP. NAME* [redacted]

FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Northern New Mexico College**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: [redacted]

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. [redacted]	0.00	0.00	1.00	[redacted]	
2. [redacted]	0.00	0.00	1.00	[redacted]	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	11,925	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	1.00	5,012	
3. (0) GRADUATE STUDENTS				0	
4. (1) UNDERGRADUATE STUDENTS				3,840	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				20,777	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				6,268	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				27,045	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) **Science DMZ Estimated Cost $ 300,000**					
TOTAL EQUIPMENT				300,000	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				3,711	
2. INTERNATIONAL				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				330,756	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **(Rate: , Base:)**					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				330,756	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				330,756	

M. COST SHARING PROPOSED LEVEL $ 0 | AGREED LEVEL IF DIFFERENT $

PI/PD NAME: [redacted]

ORG. REP. NAME*: [redacted]

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

2 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION	FOR NSF USE ONLY		
Northern New Mexico College	PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR [redacted]	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. [redacted]	0.00	0.00	2.00	[redacted]	
2. [redacted]	0.00	0.00	2.00	[redacted]	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	4.00	23,850	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	1.00	5,012	
3. (**0**) GRADUATE STUDENTS				0	
4. (**1**) UNDERGRADUATE STUDENTS				3,840	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (**0**) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				32,702	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				10,204	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				42,906	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ 300,000					
TOTAL EQUIPMENT				300,000	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)				7,094	
2. INTERNATIONAL				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				350,000	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				350,000	
K. SMALL BUSINESS FEE				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				350,000	

M. COST SHARING PROPOSED LEVEL $ **0** | AGREED LEVEL IF DIFFERENT $

PI/PD NAME [redacted]

ORG. REP. NAME* [redacted]

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

Budget Justification

(A) Senior Personnel Costs:

Compensation for the Principal Investigator, [redacted], who earns [redacted] and is on an 11-month contract at Northern, will have a 1.0-Summer month salary of [redacted] in Year 1 and Year 2. Over the course of the two-year grant, [redacted] will serve as the Principal Investigator and will be responsible for project implementation, management and reporting; and overall monitoring of the project, including working closely with the two Co-PI's, the IT Department and the Senior Personnel. This level of administrative commitment requires 1.0-Summer month compensation. **Total PI compensation is $13,669 for the two-year period.**

[redacted], Co-PI, who earns [redacted] and is on an 110-month contract at Northern, will have a 1.0-Summer month salary of [redacted] in Year 1 and Year 2. Over the course of the two-year grant, he will be responsible for the coordination of the science labs (biology, chemistry and environmental sciences) and deployment of the access layer switches. In addition, [redacted] will also be responsible for supporting the PI in project implementation, management and reporting. This level of administrative and coordination commitment requires a 1.0-Summer month salary. **Total Co-PI compensation is $10,182 for the two-year period.**

(B) Other Personnel Costs:

Other Professionals (Technician): This technician, who earns $45,112 and is on a 9-month contract at Northern, will have a 1.0 Summer-month salary of $5012 in **Year 2 only** to work with the IT Department on the initial deployment of the campus network monitoring system (CNMS), which will implement the perfSONAR measurement points and the IT Netflow collector in order to enable network and security monitoring, network planning, and traffic analysis to include identification of network bottlenecks. **Total Year 2 salary: $5,012.**

Undergraduate Student: Compensation for one undergraduate student in **Year 2 only**. This budget includes a salary of $3,840 in Year 2 for one undergraduate student at a rate of $12/hour for 10 hours per week over 32 weeks, for a total salary of $3,840 in Year 2. The student will support the PI, Co-PI's, and IT Department during the two academic semesters in the coordination and deployment of the access layer switches, and will support the IT Department in the continued maintenance of the Science DMZ. **Total Year 2 salary: $3,840.**

Year 1 Total Salary for PI and Co-PI is $11,925.

Year 2 Total Salary for all Personnel is $20,778.

The Total Salary for Year 1 and Year 2 is $32,703.

(C) Fringe Benefits: A 33% fringe benefit rate is included for the PI and Co-PI in Year 1 and Year 2. A 33% fringe benefit rate for the Other Professional, and a 19% fringe benefit rate for the undergraduate student, is included in Year 2.

Year 1 Total Fringe Benefits is $3,936.

Year 2 Total Fringe Benefits is $6,268.

The Total Fringe Benefits for Year 1 and Year 2 is $10,204.

(D) Equipment: Equipment will only be purchased after reeeiving approval from NSF after the Year 1 annual report is approved. Science DMZ equipment is estimated at $300,000 and is included in the Year 2 budget.

The Total Estimated Equipment Budget is $300,000 and is listed in Year 2.

(E) Travel:

Year 1: The PI and Co-PI will travel to the University of New Mexico in Albuquerque (ABQ), NM (175 miles round trip from Espanola, NM) in Year 1. For the first six months of the grant period, travel will take place once per month for a total of six trips in the first half of the year. Ground transportation (175 miles at $0.32/mile) and per diem ($50 per person per day) for two people (total of $100 per day per trip) is listed in the budget in Year 1 for a total of $156 per trip. Cost for six trips equals $936. For the second half of Year 1, travel will take place every other month, for a total of three trips. Ground transportation (175 miles at $0.32/mile) and per diem ($50 per person per day) for two people (total of $100 per day per trip) is listed in the budget for the second half of Year 1 for a total of $156 per trip. Cost for three trips equals $468. Year 1 Total travel to UNM equals $1,404.

PI travel to Principle Investigators meeting in DC (=175 miles round trip to ABQ airport x 0.32/ mile)+($75 per diem x 3 days + 2 nights at $200/night +592 flight) for a total trip cost of $1,273.

Finally, the PI will travel to the New Mexico Technology in Education (NMTIE) meeting in ABQ (=175 miles round trip x 0.32/mile + $50 per diem x 4 days + 3 nights at $150/night) in Nov 2015. The meeting will take place at the Hotel Albuquerque at Old Town. Total estimated cost to participate in this meeting is $706.

Year 1 Total Travel is $3,383.

Year 2: The PI will travel to the annual PI meeting in DC. Estimated costs include air fare at $600, three nights of hotel at $200/night, 4 days of per diem at $50 per day, ground transportation to the ABQ airport (180 miles x 0.32/mile), and $45 for airport transfers during conference for a total travel line item of $1,503.

The PI will also travel to the American Society for Engineering Education conference for the purpose of disseminating the results of the new Science DMZ. Estimated costs include air fare at $600, three nights of hotel at $200/night, 4 days of per diem at $50 per day, ground transportation to the ABQ airport (180 miles x 0.32/mile), and $45 for airport transfers during conference for a total travel line item of $1,503.

Finally, in Year 2 the PI will travel again to the New Mexico Technology in Education (NMTIE) meeting in ABQ (=175 miles round trip x 0.32/mile + $50 per diem x 4 days + 3 nights at $150/night) in Nov 2016. The meeting will take place at the Hotel Albuquerque at Old Town. Total estimated cost to participate in this meeting is $706.

Year 2 Total Travel is $3,711.

Total Travel for Year 1 and Year 2 is $7,094.

Year 1 Total Direct Costs are $19,244.

Year 2 Total Direct Costs are $330,756.

Total Direct Costs for Year 1 and Year 2 is $350,000.

(I) Indirect costs: The Northern F&A rate issued by the Department of Health and Human Services is 30% of the Direct Costs.

No Indirect Costs will be applied to this proposal.